SAN JUAN RIVER MONITORING PLAN

AND PROTOCOLS

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SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

U.S. FISH AND WILDLIFE SERVICE

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RECOVERY IMPLEMENTATION PROGRAM
MONITORING PLAN AND PROTOCOLS

In 1991, the San Juan River Seven-Year Research Program was initiated. Subsequently, in 1992, the Research Program was place under the auspices of the San Juan River Basin Recovery Implementation Program (SJRIP). The Research Program involved a variety of activities designed to characterize the status of the resident fish community (particularly the federally-protected Colorado pikeminnow, *Ptychocheilus lucius*, and razorback sucker, *Xyrauchen texanus*); to identify and quantify those factors (biotic and abiotic) that may be limiting protected fish species, as well as other native fish species; and to identify management and conservation activities that may contribute to recovery of protected species. Much of the research begun under the Seven-Year Research Program has been completed and a variety of management and conservation activities initiated.

To guide and provide a means of evaluating progress under the SJRIP the Long Range Implementation Plan was drafted. It was designed to provide for "adaptive management" (Section 4.7 of SJRIP Long Range Plan) wherein research and particularly management/conservation activities are modified to reflect new information. To aid in the practice of adaptive management, the Long Range Plan also directed that "A long-term monitoring program be developed and implemented…" In Section 5.7.1, development and implementation of "a long-term standardized monitoring program to identify changes in the endangered and other native fish populations, status, distributions, and habitat conditions" is identified as a "Milestone."

Prior to and during the Seven-Year Research effort, several factors were identified that might limit or adversely affect the status of native fishes, particularly Colorado pikeminnow and razorback sucker, in the San Juan River. Briefly, these are;

- low population sizes of Colorado pikeminnow and razorback sucker,
- availability of suitable/needed habitats for completion of life history stages,
- absence of "natural" flow regime (high spring runoff, low summer and winter base flows, with storm generated flow spikes),
- water quality (temperature and contaminants),
- nonnative fishes (predators and competitors), and
- disease.

The SJRIP has, as one of its two primary goals, the conservation of populations of Colorado pikeminnow and razorback sucker in the San Juan River basin. To aid in the evaluation of achievement of these Program goals, the following Monitoring Plan goals were developed.

1. Track the status and trends of endangered and other fish populations in the San Juan River.
2. Track changes in abiotic parameters, including water quality, channel morphology, and habitat, important to the fish community.
3. Utilize data collected under Goals 1 and 2 to help assess progress towards recovery of endangered fish species.

Meeting these goals will be accomplished by achieving the following objectives. These objectives form the foundation for the monitoring actions identified. Objectives are listed as they relate to each of the three SJRIP Monitoring Plan goals.

1. Track the status and trends of endangered and other fish populations in the San Juan River;
    a. determine relative annual reproductive success of Colorado pikeminnow and razorback sucker and
    b. determine population trends, including size-structure, of adult and juvenile fishes of the San Juan River.
2. Track changes in abiotic parameters, including water quality, channel morphology, and habitat, important to the fish community;
    a. track changes in selected water quality parameters,
    b. determine changes in channel morphology and substrate composition,
    c. determine changes in cobble bar characteristics, including suspected and potential spawning bars,
    d. determine trends in quantity and quality of low-velocity habitats, and
    e. determine trends in habitat diversity and abundance.
3. Utilize data collected under Goals 1 and 2 to help determine progress towards recovery of the endangered fish species.
    a. produce annual summaries of monitoring results and
    b. provide detailed analyses of data collected to help determine progress towards endangered species recovery in 3 years and thence every 5 years.

The San Juan River Monitoring Program is comprised of two major components and each of these is divided into several discrete monitoring activities, each with its specific protocol. Monitoring activities will focus on the reach of the San Juan River between its confluence with the Animas River (River Mile [RM] 180.0) and Clay Hills Crossing (RM 3.0). The monitoring protocols detailed herein were developed from methodologies used during the Seven-Year Research effort. These methods were based upon published literature, the professional experience of each researcher, peer discussions and review, and project evaluations. During the Seven-Year Research effort, methods were sometimes modified to meet the exigencies of the San Juan River, to incorporate new information and technologies, or to improve efficiency of data collection and quality of data collected. Modifications of methods were implemented after peer discussion and

review. The justification(s) for and explanation of modifications were detailed in annual or project completion reports.

Data (biotic and abiotic) collected during the Seven-Year Research effort were analyzed, using multivariate statistical procedures, to define and delimit sampling increments for several monitoring protocols. Abiotic data were used to define eight geomorphic reaches of the San Juan River between Navajo Dam and Lake Powell (Bliesner and Lamarra, 2000). Six of these reaches (Reach 6 through 1) encompass the river reach subject to routine monitoring (Animas and San Juan rivers confluence to Clay Hills Crossing). Abiotic and biotic data were analyzed to determine the linear frequency at which much of the biological monitoring would be conducted. These analyses indicated that y-o-y/small-bodied and subadult-adult/large-bodied fishes monitoring activities should be conducted every third mile. Departures from this sampling frequency are detailed and justified in the appropriate sections. Abiotic monitoring efforts are generally linked to geomorphic reaches, except that habitat monitoring would occur in 3-mile increments to overlay y-o-y/small-bodied and subadult-adult/large-bodied sampling with 2 of every 3 miles sampled.

ICTHYOFAUNAL MONITORING

LARVAL FISH—DRIFT SAMPLING (COLORADO PIKEMINNOW)
Objectives 1a, 3a, and 3b

Sampling for drifting (larval) Colorado pikeminnow, independent of flow, will be conducted from 10 July through 30 August. The permanent upstream larval fish drift monitoring site will be located about RM 128 (near Whirlpool) and lower site will be at Mexican Hat (ca. RM 53). The latitude and longitude of each site will be determined with a GPS unit.

Sampling for drifting (larval) Colorado pikeminnow will be initiated each year by late June or early July (may vary one or two weeks depending upon anticipated spring runoff). The Moore Egg Collector (Altenbach et al., 2000) will be used for collection of drifting larvae. An advantage this device has over drift nets is that under low or moderate flow, drift can be immediately sorted (while MEC operating). Thus, laboratory time for picking samples is reduced. Additionally, data gathered with MEC is comparable to that collected with drift nets.

The Moore Egg Collector (MEC) is a sluice-box-like device with a rectangular opening at its anterior end (W = 42 cm, H = 33 cm), parallel wooden sides (L = 107 cm) and an open top. The bottom is framed nylon window screen (1.6 mm-mesh) installed at a 23° angle relative to bottom mounting bar. Mounting bars are attached near the posterior end of the mouth and perpendicular to sides. The MEC is set just below the water surface, which reduces the collection of floating debris and the wedge-shaped water diverter, positioned on the top of the front flume, reduces drag under high-velocity conditions.

During operation, the MEC is held in place by the force of water pushing against steel fence posts (T-posts) driven into the stream bottom. Electric fence insulating brackets are attached to each T-post to allow vertical adjustment of the MEC. The posterior T-post and bracket support the rear of the collecting device. Drift that enters the MEC accumulates on the screen at the water-air interface where it can be easily gathered, counted, and collected with an eye-dropper or larval forceps. Collected drift is placed in labeled collection container.

A single MEC will be fished twice each day (morning and evening) for at least two hours per set. Morning sampling will begin at dawn and the evening set will begin about one hour before dusk. The top of the MEC will be 5 to 10 cm below water surface and about 30 cm above the channel bed; flow volume will influence whether this can always be accomplished. The MEC will be placed near shore in moderate-velocity current. Water depth at collection location will be measured at beginning and end of each set.

Fishes collected during a sampling set will be immediately preserved in sampling jars containing unique field numbers and 5% buffered formalin. If the amount of debris precludes in-river picking of drift, all material collected on the screen will be retained (following the same protocol for drift nets) in one-gallon plastic bags, labeled with unique field numbers, and preserved in 10% buffered formalin. Bulk drift material will be allowed to "cure" for at least two days before samples are sorted and fish specimens separated from debris. All samples will be processed (sorted, identified, and enumerated) and specimens accessioned into the Museum of Southwestern Biology, University of New Mexico. Each specimen will be assigned to a developmental stage, following Snyder (1976). Fish too small to be accurately identified to species or genus will be assigned familial designations. Specimens also will be assigned to a drift or incidental category (Table 1). The former refers to individuals with minimal or no control over their longitudinal movement. The latter classification refers to individuals whose developmental stage should have allowed them to avoid passive capture. Fish deemed "incidental" will be reported in the initial data summary, but will not be considered in subsequent drift analyses. Fish density will be calculated as the number of individuals per 100 m^3 of water filtered.

Table 1. List of fish species captured in drift-nets, 1991 – 1997, and approximate size (mm, TL) for drifting larvae. Larger and more developed fish are incidental captures. A dash (-) indicates those species whose larvae do not drift.

SPECIES	MAXIMUM DRIFT LENGTH (mm, TL
Cyprinella lutrensis (red shiner)	12
Cyprinus carpio(common carp)	12
Gila robusta (roundtail chub)	14
Ptychocheilus lucius (Colorado pikeminnow)	14
Pimephales promelas (fathead minnow)	12
Rhinichthys osculus (speckled dace)	12
Catostomus discobolus (bluehead sucker)	15
Catostomus latipinnis (flannelmouth sucker)	20
Ameiurus melas (black bullhead)	-
Ictalurus punctatus (channel catfish)	25
Gambusia affinis (western mosquitofish)	-
Micropterus salmoides (largemouth bass)	-

Water quality parameters (water temperature, dissolved oxygen, specific conductance, and salinity) will be measured (mid-water column) at each site with a handheld, micro-processor based YSI Model 85 digital meter. Water temperature will be recorded hourly for duration of sampling season by a thermograph deployed at each drift station. All information obtained for each sampling foray/site will be recorded on standard field forms (Appendix I); completed forms will be accessioned to the Museum of Southwestern Biology (MSB). In addition to measured parameters, notes on general conditions (e.g., weather and water turbidity) will be recorded on each field form.

Annual reports on results of passive drift netting will be prepared and submitted by 31 March of the year following completion of the work. The report will provide summary statistics for each larval fish-sampling site, and will minimally include species and number of specimens per species per day, relevant catch-rate data, and water quality information. Catch rates for morning and evening sets on the same day will be compared using a paired-comparisons *t*-test. This test also will be used to evaluate differences in catch rate between sampling sites. Original field notes will be retained in the MSB Division of Fishes and collection data will be electronically stored in a permanent MSB database program. Electronic copies of the field and collection data will be transferred to the San Juan River database manager by 31 March of the year following completion of work. Photocopies of all field notes will be archived at USFWS NMFRO Albuquerque office. Three- and five-year summary reports that integrate and synthesize data from annual reports will be prepared. Appropriate statistical procedures will be used to analyze data and assess differences in fish densities by locality, sampling date, and sampling time.

LARVAL FISH—SEINING (RAZORBACK SUCKER)
Objectives 1a, 3a, and 3b

The sampling methods to be employed for monitoring of razorback sucker are those that yielded the first documentation (1998) of reproduction by this species in the San Juan River. This sampling protocol will be evaluated each year for five years to determine the most efficient and informative methodology for this phase of the monitoring program.

The sampling area for this study will be the San Juan River between RM 128 and Clay Hills (RM 3). For this investigation, the study area will be divided into two discrete reaches; RM 128 to RM 76 (Sand Island) and RM 76 to RM 3 (Clay Hills). Sampling will begin during the first week of April and conclude during the first week of June. As with larval Colorado pikeminnow drift monitoring, sampling period will be independent of flow. A sampling foray, defined as a collecting effort through either one of the reaches, will be conducted every 10 days. Non-motorized inflatable rafts will be the transport used to traverse study reaches.

The suite of mesohabitats defined as low-velocity habitats will be sampled at a frequency of at least three times every 5 miles. All backwaters will be sampled regardless of the number of collections obtained from other low-velocity habitats. Location of sample sites will be recorded on aerial photographs or videographs of the San Juan River (provided by SJRIP). In addition, sample locations will also be determined with GPS units. Habitat type (following SJRIP definitions), length, maximum depth, and substrate of each habitat will be recorded. Larval fish will be collected with 1.2 or 1.8 x 1.2 m (1.6 mm mesh) seines or light traps. The number of seine hauls per site and surface area of habitat sampled will be recorded. Water quality parameters (water temperature, dissolved oxygen, specific conductance, and salinity) will be measured (mid-water column) at each site with a handheld, micro-processor based YSI Model 85 digital meter. Ambient temperature will also be determined. In addition to measured parameters, notes on general conditions (e.g., weather and water turbidity) will be recorded on each field form. Specimens will be preserved in 10% buffered formalin for laboratory processing. Catch per unit effort will be calculated as number of fish per m^2 seined for seine samples and number of fish per hour for light-trap samples.

All specimens captured under the above protocol will be procesed and handled in the same manner as those obtained in larval drift studies. The annual and summary reports for larval razorback sucker monitoring will likewise be similar to that for larval drift monitoring. Field information will be recorded on standard field forms (Appendix I); completed forms will be accessioned to the MSB. Annual reports will be prepared and submitted by 31 March of the year following completion of work. The report will provide summary statistics by sampling foray, and will minimally include species and number of specimens per species per trip, relevant catch-rate data, and water quality information. Original field notes will be retained in the MSB Division of Fishes and collection information will be electronically stored in a permanent MSB database program. Photocopies of all field notes will be archived with USFWS NMFRO

Albuquerque office. Electronic copies of the field and collection data will be transferred to the San Juan River database manager by 31 March of the year following completion of the work. A three- and subsequently five-year summary reports, which integrate and synthesize data from annual reports, will be prepared. Appropriate statistical procedures will be used to analyze data and assess differences in fish densities by locality, sampling date, and sampling time.

YOUNG-OF-YEAR AND SMALL-BODIED FISHES
Objectives 1a, 1b, 3a, and 3b

Young-of-year and small-bodied fishes monitoring includes Geomorphic Reaches 6 through 1 (RM 180 to RM 3), with Reach 1 being the most downstream. Secondary and primary channel sampling will occur every third mile (Designated Mile][DM]) within the study reach, beginning with RM 180-179 (San Juan and Animas rivers confluence). Secondary channels are defined as channels having less that 25% of the volume of flow (visually estimated) at time of sampling and at least 300 m in length. Inflow at top of a channel is not necessary for it to be classified as a secondary channel. If any portion of a secondary channel (except debouchement) is within a DM, the secondary channel will be sampled. Sampling within a secondary channel will be at least one-fourth channel length from infow to and outflow from to minimize primary channel faunal influences. Primary channel sampling may be conducted throughout the DM. All backwaters and embayments (>25 m^2) associated with the primary channel within a DM will be sampled. In addition to sampling secondary channels within each DM, eight secondary channels will be sampled annually, regardless of occurrence within a DM. Each of these channels normally has surface water at typical autumn discharge levels (500 to 2000 cfs). Four of these secondary channels (RM 126.6—127.2, RM 131.3—132.3, RM 133.7—134.3, and 139.5—140.9) are in New Mexico and four (RM90---90.8, RM 94.05—94.3, RM 110.3—111.1, and RM 115.7—116.5) are in Utah. Each of these channels was sampled during autumn monitoring from 1993 through 1998. Young-of-year and small-bodied fishes monitoring will occur during mid-September through mid-October each year in conjunction with subadult-adult/large-bodied fish monitoring.

All mesohabitats (e.g., backwater, pool, shoal, run, and riffle; defined by Bliesner and Lamarra, 2000) present within each DM (secondary and primary channels) will be sampled in approximate proportion to their availability within the DM. Primary channel sampling will occur mainly along the shoreline, but will include off-shore riffle habitats, if present, within the DM. Double-weighted drag seines will be the primary capture tool (3.2 m x 1.6 m or 3.8 m x 1.6m, 4 mm mesh). A 12 v backpack electrofisher may be used in combination with a block seine to sample riffles. In mesohabitats having visible surface flow, seine hauls will be made in a downstream direction parallel or diagonal to shore. In mesohabitats where flow is imperceptible or where habitat has cover (e.g., rootwad or boulder), the seine haul will be made in a manner that entraps fish. Seine hauls in flowing and still water will be 10 m or less. Regardless of the type of seine haul, the leadline will be in contact with the channel bottom. Where a seine and backpack electrofisher are used in tandem, the seine will be anchored perpendicular to flow.

Electrofishing will begin about 10 m, or less, upstream of seine. Surveyor flags will be used to mark the boundaries of the sampled portion of each mesohabitat. At least one worker participating in the y-o-y/small-bodied fish sampling will have experience seining in a variety of conditions and will be familiar with the native and nonnative fishes of the San Juan River.

Each mesohabitat will be sampled separately, with data (unique identifier for each mesohabitat) for each recorded separately. The number of seine hauls, total area (m^2) seined, and type of mesohabitat will be recorded on standard field forms (Appendix II). Specimens collected in each mesohabitat will be inspected to determine if any rare fishes (Colorado pikeminnow, roundtail chub, and razorback sucker) are present. If a rare fish is captured, it will be identified, total length ($\pm$ 1 mm) and weight ($\pm$ 1 g) determined, and released. Any rare fish > 150 mm TL will be scanned to determine presence of a PIT tag. If none is present, a PIT tag will be implanted. All pertinent data (i.e., total and standard lengths, weight, PIT tag code, mesohabitat, water depth, substrate, and cover) will be recorded. All sub-adult and adult large-bodied native fishes (e.g., flannelmouth and bluehead suckers) will be weighed, measured, and released. All other specimens will be preserved in 10 % formalin and returned to laboratory for identification, enumeration, and measurement (total length). Field collection number, habitat number, and river mile will be recorded on a waterproof label and placed in each container. Location of site (latitude and longitude) will be determined with a GPS unit. Identification of all retained rare fishes will be confirmed by personnel of the Museum of Southwestern Biology. Preserved specimens will be accessioned to New Mexico Department of Game and Fish Collection of Fishes or Museum of Southwestern Biology.

All backwaters and embayments (> 25 m^2) within each DM will be sampled. During periods of low flow, secondary channel mouths frequently function as backwaters or embayments. Secondary channels without surface inflow will be treated as backwater/embayment habitat. All specimens collected, except rare fishes, will be retained and returned to laboratory for identification and enumeration. All rare fish identified in the field will be measured and released; those > 150 mm TL will be PIT tagged. Data collection and recording of relevant information (including GPS determined location) will be the same as for secondary and primary channel collections (Appendix II).

Water temperature, dissolved oxygen, specific conductance, and salinity will be measured in each sampled secondary channel, at primary channel sites, and in backwaters/embayments with a handheld, micro-processor based YSI Model 85 digital meter. Secondary channel water quality data will be obtained the same area fish specimens collected and will be done prior to fish sampling. All water quality data will be recorded on standard field forms.

Data from y-o-y/small-bodied fishes monitoring will be submitted annually (written and electronic formats) by 31 March of the year following the effort. The report will be mainly a tabular presentation of data with important findings discussed. Tables and figures will present information on fishes collected per geomorphic reach, and

density per species per geomorphic reach, and relation of species abundance to flow attributes. All relevant information (habitat and somatic) on rare fishes will be presented. Original field notes will be retained by the entity responsible for y-o-y/small-bodied fish monitoring. Photocopies of all field notes will be archived with USFWS NMFRO Albuquerque office. Summary reports (the first in three years [2002] and thence every five years) will provide detailed analyses of data collected, discussion of detected trends and relation to abiotic and other biotic factors, and evaluation of methods to monitor y-o-y/small-bodied fishes in the San Juan River. Analysis of variance (ANOVA) will be used to evaluate among year and reach differences in species densities. Linear and multiple regression will be used to assess relationship between species abundance and flow attributes. Similarity and diversity indices will be used to characterize trends in fish assemblages among reaches and years.

SUB-ADULT—ADULT/LARGE-BODIED FISH
Objectives 1b, 3a, and 3b

Annual monitoring of large-bodied fishes in the San Juan River between the confluence of the Animas and San Juan rivers (RM 180) and Clay Hills Crossing (RM 3) will occur between mid-September and mid-October each year. Monitoring will occur mainly in the primary channel, secondary channels with sufficient flow to support an electrofishing raft will also be sampled.

Raft-mounted electrofishing gear will be used to collect fishes. Rafts will not be motorized. Output of electrofishing units will not exceed 400 v and 6 amps, pulsed DC. Two electrofishing rafts will be deployed along opposite shorelines to collect fishes. Each raft will proceed downstream perpendicular to shore at a fairly constant speed with continuous electrical output. Each electrofishing crew will consist of one raft operator (rower) and one netter; both will be experienced in raft-mounted fish collecting techniques. Effort will be made to net all fishes stunned by the electrofisher. To minimize injury to netted fish, they will be promptly dumped in a live-well located behind the netting deck; netted fish will not be repeatedly swept through the electrical field. Sampling will be conducted in 1-mile increments with two of every three miles being sampled. Sampling effort will be recorded as elapsed time electrofished by each raft per river mile. All fish captured will be identified and enumerated by life stage (juvenile, sub-adult, and adult) and species. Fish will be identified by six-letter codes (first three letters of genus and first three letters of species). All fish captured every fourth sampled mile (DM) will be weighed ($\pm$ 5 g) and measured $\pm$ 1 mm total and standard length. All nonnative fishes will be removed and all native fishes will be returned to river alive.

Each rare fish captured will be weighed ($\pm$ 1 g if < 200 mm TL and $\pm$ 5 g if $\geq$ 201) and measured ($\pm$ 1 mm SL and TL), sex determined (if possible), and scanned for PIT tag. If a specimen does not have a PIT tag, such will be implanted (if specimen > 150 mm TL).

Water temperature will be measured at each DM. Each river mile sampled by each raft will be treated as a separate collection, with a unique field number. All data will be recorded on standard field forms (Appendix III). Rare fish information will be recorded on the standard field form for the river mile in which it was captured.

Annual reports, summarizing data obtained during large-bodied fish monitoring will be submitted (written and electronic formats) by 31 March of the year following the effort. The annual report will minimally contain a summary of species captured, species density (number per hour elapsed electrofishing time) by geomorphic reach, size-structure of common species populations (flannelmouth sucker, bluehead sucker, channel catfish, and common carp) by geomorphic reach, and rare fishes captured (including somatic data). Original field notes will be retained by the entity responsible for conducting large-bodied fish monitoring. Photocopies of all field notes will be archived with USFWS NMFRO Albuquerque office. Summary reports (the first in three years [2002] and thence every five years) will include an overview of trends in species populations (including size-structure and condition), distribution patterns, and relation of status of species populations to abiotic and other biotic conditions. Descriptive statistics (e.g., mean, mode, range, standard deviation, and standard error) of sampling results will be provided. Statistical methods to evaluate changes in fish assemblages will include non-parametric (Kruskal-Wallis and Kolomogorov-Smirov) and parametric (paired *t*-test, analysis of variance, and analysis of covariance tests), and linear regression. Various population-estimates models (manually generated such as Schnabel or Petersen index estimates or computer programs such as CAPTURE or MARK [Cormack-Jolly-Seber]) will also be used to analyze data..

GEOMORPHOLOGY AND HABITAT MONITORING

CHANNEL MORPHOLOGY--RIVER TRANSECTS
Objectives 2a and 3a

Bed material deposition and scour will be monitored in five of the six geomorphic reaches included in the long-term monitoring study area (RM 180 to RM 3). Reach 2 (RM 67 to RM 17) is canyon-bound and is not subject to channel change; thus it will not be monitored. Two to three cross-sections in each geomorphic reach were identified for monitoring. Each cross-section will be surveyed across the active river channel pre- and post-runoff each year. At least one cross-section in each reach will span the floodplain and the full width will be surveyed every fifth year to monitor the effect of high flows on the floodplain. Table 2 lists the cross-sections in each geomorphic reach. The cross sections were selected from those established in 1962 (lettered cross-sections), those established in 1992, and new cross-sections (where existing cross-sections were not representative of a geomorphic reach). Monitoring program cross-sections are coded by geomorphic reach (e.g., CS6-02 = second cross-section in geomorphic reach 6).

Table 2. San Juan River channel morphology monitoring cross-section locations by geomorphic reach.

Geomorphic Reach	X-Section No.	Former Identification	River mile
6	CS6-01	NEW	175.0
	CS6-02	RT-01	168.3
	CS6-03	RT-02	154.4
5	CS5-01	RT-03	142.7
	CS5-02	RT-04	136.6
	CS5-03*	RT-05	132.7
4	CS4-01	RT-06	124.0
	CS4-02	RT-07	122.1
	CS4-03*	Section E	118.2
3	CS3-01	RT-09	90.8
	CS3-02*	RT-10	82.3**
	CS3-03	RT-11	70.0
1	CS1-01	C-01	12.7
	CS1-02	C-02	4.1

*Valley-wide cross-sections surveyed every fifth year to monitor floodplain changes
**Valley-wide cross-section located at RM 82.2

Water and channel depths data will be obtained by stretching a marked cable across river between anchor points for each transect and measuring the channel depth relative to a local bench mark. River depths will be measured at 5 ft increments unless cross-section length exceeds 300 ft. In such a situation, areas of the cross-section that have a change in depth of less than 0.5 ft in 10 ft will be surveyed in 10 ft increments. Substrate type at point of depth measurement will be characterized as sand or gravel/cobble and recorded. The full-width floodplain surveys will be completed with total station or GPS survey equipment outside the active channel at points representing changes in grade (e.g., top of hill, edge of channel, toe of bank). The data sheet for recording field information is in Appendix IV.

Survey data will be plotted using Autocad and average and maximum change in channel depth since the preceding survey will be computed. Substrate attributes will be noted in the files. Substrate composition, expressed as percent of total width for substrate type, will be completed for each cross-section.

Data will be summarized and reported annually by 31 March of the year following its collection. Annual reports (written and electronic) will contain cross-section plots, change in average cross-section elevation from pre- to post-runoff and from the previous year, and percent substrate change by type (sand or gravel/cobble). Field forms will be retained by the entity performing this task. Photocopies of all field forms will be archived at USFWS NMFRO office in Albuquerque. The flow/morphology relationships will be analyzed in three years (2002) for verification or adjustment and thence every five years.

COBBLE BAR CHARACTERIZATION
Objectives 2b and 3a

Four locations (cobble bars) on the San Juan River (RM 173.7, RM 168.4, RM 132.0, and RM 131.0) were identified as having attributes suitable for spawning by Colorado pikeminnow. Topographic surveys will be completed annually for each of these cobble bars, utilizing total station or GPS survey equipment, with control provided by established bench marks at each location. Surveys will be completed as soon as practical (flow of $\leq$ 1000 cfs) after spring runoff, usually during late July or early August. The same locations will be surveyed each year to enable comparisons among years. The following procedures will be followed in completing surveys:

1. Establish two permanent bench marks on the first survey and use these bench marks for subsequent surveys. Double shots (one before and one after survey) will be taken at bench marks. Elevations must close within 0.1 ft and positions within 1.0 ft or the survey must be repeated.

2. Based on prior surveys or visual inspection, the extent of the bar to be surveyed will be determined and marked. This boundary will be extended at least 20 ft.

3. Position and elevation readings will be taken on a grid not greater than 30 ft for relatively flat, large bars (> 1.0 acre) and not more than 10 ft for smaller bars with greater topographic relief. Reading points will be at all grade breaks at $\leq$ 10 ft increments. At least 100 readings will be completed at each bar.

4. Descriptions of each point will be recorded and all edge-of-water shots will be noted.

5. Instrument location and elevation relative to bench marks will be recorded.

6. Depth to embeddedness and survey point number will be recorded for all non-benchmark points.

Concurrent with the above effort, physical structure of each cobble bar will be assessed by measurement of randomly selected particles of surface bed material. Particles will be selected by the Wolman pebble count method (Wolman, 1954) over the full extent of the bar within the survey boundary. A minimum of 200 samples will be collected in a linear pattern over the bar with a spacing of about 8 to 10 ft (3 steps) within the line and between lines. Particle size will be determined by sieving particles through a square hole in an aluminum plate, cut to represent an equivalent screen size from 1 through 10 cm at 1-cm increments, then 2-cm increments through 20 cm. Particles larger than 20 cm will be recorded as greater than 20 cm. Interstitial material smaller than 1 cm

will be recorded as < 1 cm but is not included in analysis of size distribution. The number of samples 1 cm or larger will not be less than 100. The percent of samples less than 1 cm will be recorded. The field data sheet for this activity is in Appendix V.

Depth of open interstitial space (depth to embeddedness) will be measured at the same time and location as the survey points to characterize topography of the bar over the extent of the spawning bar. Measurement will be made by a field technician working his/her hand among rocks until the fingers just touch embedded sand. Depth of penetration, measured from adjacent average cobble top-surface, will be recorded as depth of open interstitial space (Osmundson and Scheer, 1998). Coordinates of survey points will be determined with GPS or total station survey equipment. Prior to each sampling effort, field personnel that have not conducted this type of survey will be trained by an experienced sampler. Field data will be recorded on standardized forms (Appendix V).

Change in spawning bar morphology will be determined by producing three-dimensional plots of the surveyed spawning bar and subtracting the calculated volume of the current plot from volume determined in a previous survey. Amount of change (positive or negative) will be compared to flow conditions for year in question.

Size distribution of cobble at each spawning bar, as measured by the pebble-count method, will be computed and D_{16}, D_{50}, and D_{84} sizes (cobble diameter exceeded by 16, 50, and 84% of the samples) reported and compared to previous years. Depth of open interstitial space will be computed as actual depth and multiples of mean cobble diameter.

It is anticipated that spawning bars will change with time, to the point that existing bars may cease providing spawning habitat, and that others will be used as they become suitable. A longitudinal survey of the river in 1994 located and characterized bars that contained loose cobble. Similar surveys will be completed every fifth year, between RM 180 and RM116, to locate newly-formed bars that may be suitable for spawning by Colorado pikeminnow. From this survey, a new bar that is closest in proximity and condition to a lost bar will be substituted in the sampling program.

Data will be summarized and reported annually (written and electronic formats) by 31 March of the year following collection. Field forms will be retained by the entity conducting this portion of the monitoring effort. Photocopies of field forms will be archived at USFWS NMFRO Albuquerque office. Data in annual reports will include topographic survey plots showing bar surface and depth of open interstitial space, change in bar volume from previous year, mean and maximum depth of open interstitial space, and particle size distribution. Response of cobble bars to flows and long-term trends will be analyzed in three years (2002) and thence every five years.

BACKWATER/LOW VELOCITY HABITAT PHYSICAL MEASUREMENTS
Objectives 2c and 3a

To characterize trends in relative quality of backwaters, five representative backwaters within each geomorphic reach will be measured to determine water and fine sediment (<0.01 mm diameter) depth. Sampling will occur annually between 15 September and 1 November during habitat mapping efforts. These backwaters will remain the same from year-to-year, to the extent possible. If a backwater is "lost," another will be selected for sampling and retained in the sampling regime until it is "lost." The replacement backwater will be the first backwater downstream of the one lost and will have similar characteristics. Depth of sediment will be measured and recorded for "lost" backwaters. All measurements will be made at flows between 500 and 1,000 cfs. Sediment and water depths will be measured at three points in each backwater (mouth, 1/3 and 2/3 of length from mouth). Backwaters sampled will be marked on digital aerial imagery. Data will be recorded on standard field forms (Appendix VI).

Storm events will be determined by changes in flow at USGS gages near Shiprock and Four Corners, New Mexico and turbidity at Shiprock and Montezuma Creek, Utah. The need to continue this element will be assessed after five years.

Annual reports (written and electronic formats), submitted by 31 March of the year following data collection, will include a summary of backwater measurement data (location, water and sediment depth, flow at sampling, and turbidity) for each site. Field forms will be retained by the entity conducting this phase of monitoring. Runoff/storm event/backwater habitat relationships will be analyzed in three years (2002) and thence every five years.

HABITAT MAPPING
Objectives 2d and 3a

Annually, digital aerial photography or videography will be obtained for the San Juan River between RM 180 and RM 0 and printed at an approximate scale of 200 ft per inch. Thirty-eight categories of aquatic habitat (Table 3) will be mapped in the field, using digital imagery as a base map. Flights and mapping will be completed as soon after spring runoff as flows are $\leq$ 1,000 cfs and weather permits. Field mapping will be completed at flows between 500 and 1,000 cfs. Digital imagery or aerial photography will be obtained from Navajo Dam (RM 225) to Lake Powell (RM 0) every fifth year.

Table 3. Habitat mapping categories used in field mapping.

Map No.	Habitat	Map No.	Habitat	Map No.	Habitat
1	Backwater	11	Scour Run	26	Rootwad Pile
2	Backwater Pool	12	Shore Run	27	Dry Channel
3	Pool	13	Undercut Run	28	Sand Bar
4	Debris Pool	14	Riffle/Run	29	Tributary
5	Rootwad Pool	15	Riffle	30	Shoal/Riffle
6	Eddy	16	Riffle Eddy	31	Island
7	Edge Pool	17	Shore Riffle	32	Rapid
8	Shoal	18	Riffle/Chute	33	Irrigation Return
8a	Sand Shoal	19	Chute	34	Inundated Veg
8b	Cobble Shoal	20	Slackwater	35	Pocket Water
9	Shoal/Run	21	Isolated Pool	36	Boulder
9a	Sand Shoal/Run	22	Embayment	37	Waterfall
9b	Cobble Shoal/Run	24	Overhang Veg		
10	Run	25	Cobble Bar		

Mapping will be completed for 2 of every 3 river miles, matching miles sampled during large-bodied fish monitoring. Mapping will be completed in autumn with an attempt to map flows between 500 and 1,000 cfs and about the dates of autumn fish monitoring. Every fifth year, the entire 225 miles of river will be field mapped during autumn.

Field mapping will be entered into a Geographic Information System (GIS) for analysis to produce coded polygons (habitats) for which surface areas will be computed and sorted (by habitat). These data will be retrieved and analyzed by cross-tabulation of the factors being correlated (e.g., habitat area by river mile). Data will be processed and summarized by 31 March of the year following collection. Flow-habitat relationships will be examined and updated and trends in habitat change characterized in three years (2002) and thence every five years. Geographic Information System coverage of habitat mapping will be produced and included in SJRIP database annually.

WATER TEMPERATURE
Objectives 2e and 3a

Water temperature monitors will be maintained on the San Juan River at Navajo Dam, Archuleta, Farmington, Shiprock, Four Corners, Montezuma Creek, and Mexican Hat and on Animas River at Farmington. Data (daily maximum, minimum, and mean) will be downloaded twice yearly and summarized and plotted annually (by 31 March of year following collection). Recording logs (Appendix VII) will be maintained for each recording site. Recording logs will be retained by entity responsible for collection of thermal data. Photocopies of logs will be archived at USFWS NMFRO Albuquerque office.

WATER QUALITY
Objectives 2e and 3a

Twelve water quality monitoring sites (Table 4) were identified as necessary to characterize water quality in the San Juan River and key tributaries. Sampling interval will be quarterly (trimonthly) in February, May, August, and November. This temporal spacing was adopted to ensure water sampling occurs during spring runoff in the upper portion of the San Juan River basin and during winter base flows. Field data will be recorded on standard forms (Appendix VIII). A chain-of-custody record, used to track sample shipment and a sample-receipt form are also in Appendix VIII.

Table 4. San Juan River water quality monitoring sites.

Station Name	USGS ID	USGS Record	BIA Record
San Juan River near Archuleta Bridge	9355500	1958-1984	1991-1998
Gallegos Canyon near Farmington	9357255	1979-1981	1991-1998
Animas River @ Farmington	9364500	1958-1992	1991-1998
San Juan River @ Farmington	9365000	1974-1991	1991-1998
LaPlata River near Farmington	9367500	1977-1991	1994-1998
Ojo Amarillo Canyon	9367536		1993-1998
San Juan River @ Shiprock	9368000	1958-1992	1991-1998
Mancos River near Four Corners	9371005		1991-1998
San Juan River @ Four Corners	9371010	1977-1990	1991-1998
San Juan River @ Montezuma Creek	9378610		1991-1998
San Juan River @ Bluff	9379495		1991-1998
San Juan River near Bluff (@ Mex. Hat)	9379500	1974-1993	1991-1998

Chemical analyses relevant to long-term monitoring goals are listed in Table 5. Parameters listed in left column will be measured quarterly. In addition, field measurements of water temperature, pH, redox potential, specific conductance, and dissolved oxygen will be made. Annually, during low-flow periods in February, water samples will be analyzed for all parameters listed in Table 4. Turbidity will be continuously monitored at Montezuma Creek with a remote sensing turbidity monitor. Maintenance of the turbidity sensor will be recorded on a field form (Appendix VIII). Field data collection and laboratory analyses will be done using standard EPA methods, where applicable.

All data collected will be reported (written and electronic formats) annually by 31 March of the year following collection. Data will be in tabular form suitable for inclusion in the SJRIP GIS database. All field forms will be retained by the entity collecting data. Photocopies of all field forms will be archived at USFWS NMFRO Albuquerque office.

Table 5. San Juan River Monitoring Program water quality parameters.

Quarterly	Annually
Arsenic (total & dissolved)	Aluminum (total & dissolved)
Calcium (dissolved)	Barium (total & dissolved)
Copper (total & dissolved)	Manganese (total & dissolved)
Lead (total & dissolved)	Nickel (total & dissolved)
Magnesium (dissolved)	Potassium (total & dissolved)
Mercury (total & dissolved)	Strontium (total & dissolved)
Sodium (dissolved)	Orthophosphate (total & dissolved)
Selenium (total, dissolved, & total recoverable)	Chloride (dissolved)
Zinc (total & dissolved)	Ammonia (dissolved)
Alkalinity (HCO_3)	Nitrate (dissolved0
Hardness	Nitrite (dissolved)
TDS	Silica (total & dissolved)
TSS	Sulfate (dissolved)
Turbidity	

REPORTING AND COORDINATION

Annual reports will consist primarily of tabulated data (with figures and maps, as appropriate) obtained during each monitoring effort. Important findings will be presented as brief narratives. After submission of annual reports to SJRIP Biology Committee, potential changes to monitoring protocols will be discussed and evaluated the the Biology Committee. If changes are deemed appropriate, by two-thirds majority of Biology Committee, the SJRIP Monitoring Protocol will be changed accordingly. The first summary reports, synthesizing data from annual reports, will be prepared after three years of monitoring (2002) and thence summary reports will be completed every five years. Information in annual reports and particularly summary reports will be used to evaluate program progress and as a basis for practicing "adaptive" management in the SJRIP.

Minimally, summary reports on biological monitoring will contain information on patterns or trends in the abundance and size-structure of common species (native and nonnative), somatic condition of common fish species, assessments of recruitment, and longitudinal abundance and population size-structure patterns. The summary reports on monitoring abiotic conditions will be similar to biological reports in that detailed analyses and narratives of results will be presented for each monitoring activity. These reports will discuss changes in abiotic conditions (e.g., channel morphology, spawning bars, sediment dynamics) in relation to river flow regimes. Appropriate uni- and multi-variate statistical methods will be used to assess data for both biotic and abiotic monitoring efforts.

Biotic and abiotic summary reports will be issued as a single document. To the extent appropriate, linkages among biotic and abiotic information will be made and discussed in a document summary.

All data in each annual report will also be submitted on disk or by e-mail for incorporation into the SJRIP GIS database maintained on San Juan River research and monitoring activities. Annual monitoring results will be submitted to USFWS, Region 2 and SJRIP GIS database manager by 31 March of the year following collection. Three- and five-year summary reports will be due to the SJRIP Biology Committee by 1 October of the year following completion of the reporting segment. All reports should be in scientific journal style and format (e.g., The Southwestern Naturalist). All reports will be draft until reviewed and accepted by SJRIP Biology Committee. Upon acceptance of reports, Biology Committee will submit a joint annual or summary report to SJRIP Coordinating Committee within three months of final Biology Committee approval. Once annual and summary reports are accepted by the SJRIP Biology and Coordination committees, they will be made available to the public.

Other SJRIP sponsored research activities will be conducted in a manner and schedule to ensure that their field work does not interfere with or disrupt monitoring activities. If there are questions regarding this potential, the principal investigator for the research activity must communicate the nature and extent of the proposed activity with the entity responsible for the monitoring segment(s) that might be affected and the SJRIP Biology Committee. If potential conflicts are not resolvable among investigators, the matter will be taken to the SJRIP Biology Committee for resolution.

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